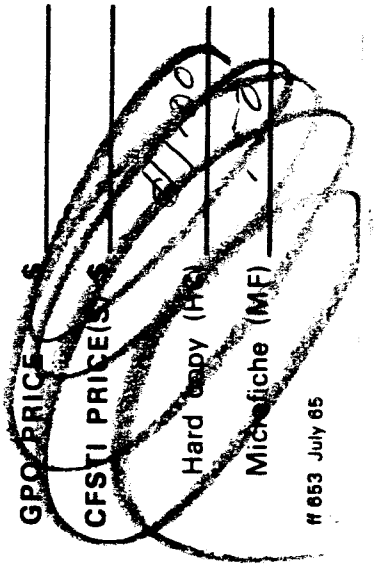
# PROGRESS REPORT

PR 91570-510-2

For the Period of August 1, 1963 through August 31, 1963




## DEVELOPMENT OF A HYDROGEN-OXYGEN SPACE POWER SUPPLY SYSTEM

NASA Contract NAS 3-2787

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## INTRODUCTION

This report is issued to comply with the requirements of NASA Contract NAS 3-2787 and to report the work accomplished during the period August 1 through August 31, 1963. The objectives of this program are to conduct an engineering study, fabrication, and test work culminating in the design of an auxiliary electric power generation unit.

This Contract, NAS 3-2787, is a continuation of NASA Contract NAS 3-2550.

## PROGRAM SCHEDULE

The program schedule is shown in Fig. 1.

## FLIGHT TYPE POWER SYSTEM DESIGN

No work was scheduled during this reporting period on flight type power system design.

## RELIABILITY AND QUALITY ASSURANCE

The Reliability and Quality Assurance Program Plan is being prepared. Due to the absence of some key personnel on vacation and military leave the completion date has been rescheduled to September 30, 1963.

## PROTOTYPE COMPONENT DEVELOPMENT

### Engine

NASA CONTRACT NAS 3-2787
PROGRAM SCHEDULE AND PROGRESS CHART

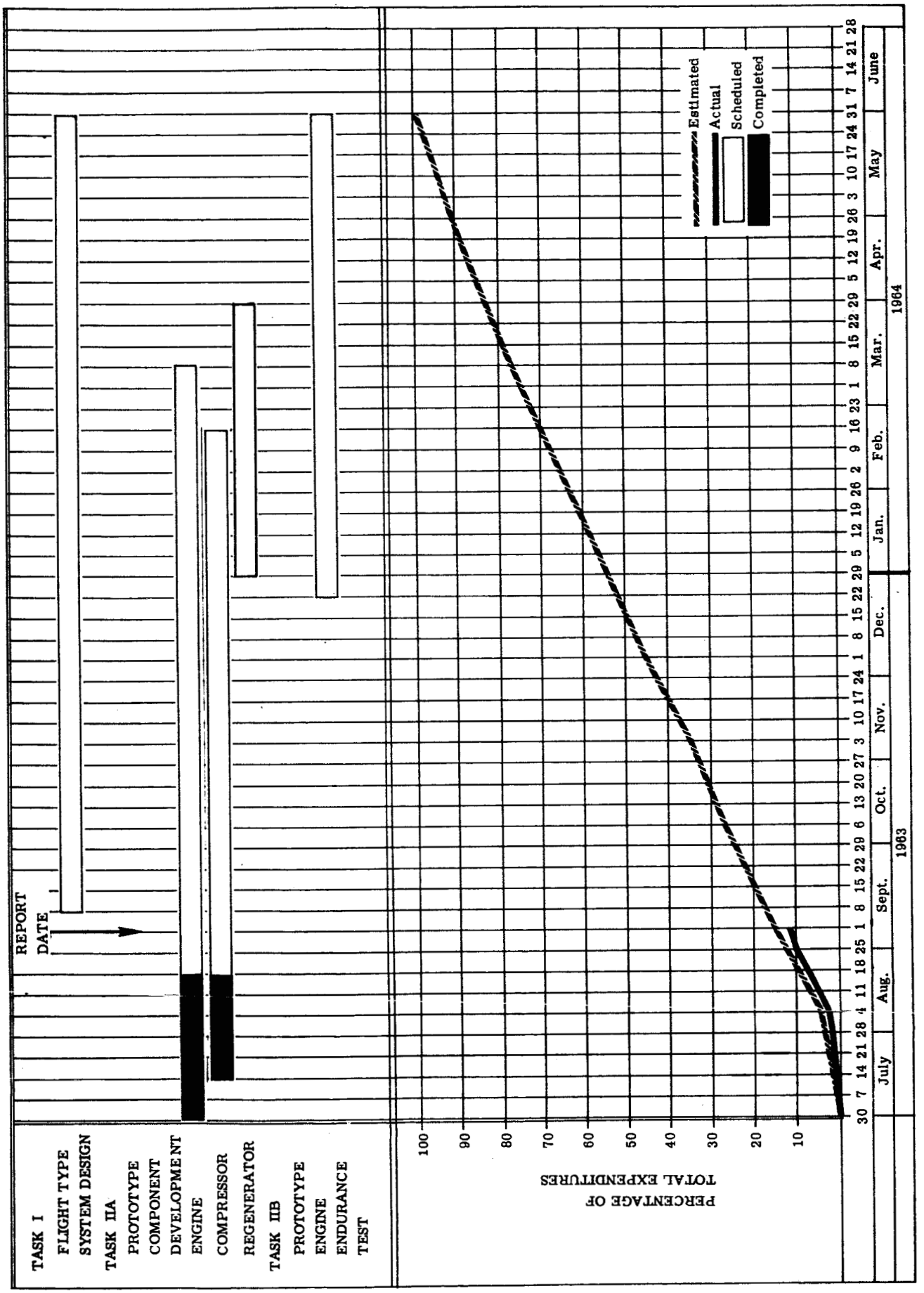


Fig. 1

Rework

Rework of the following parts has been accomplished and is in process:

1. One set of oxygen injector parts has been reworked for use in an assembly of the redesigned configuration as shown in Fig. 2 of PR 91570-510-1.

2. A second engine cylinder has been drilled for installation of wall temperature thermocouples.

3. The edge of one piston dome was chamfered to increase the exhaust blowdown area.

4. One engine upper crankcase is being reworked to provide clearance for a wider oxygen injector cam.

Redesign

The following redesign and fabrication is in process:

1. The hydrogen valve has been redesigned to the configuration shown in Fig. 2. The old design is shown in Fig. 3 for comparison. The new design changes the direction of the hydrogen flow through the valves. The valve stems are not exposed to the combustion chamber with this design. The poppet return springs oppose hydrogen supply pressure rather than combustion chamber pressure: this fact will allow the use of higher oxygen supply pressures which should result in higher combustion peak pressures and improved performance.

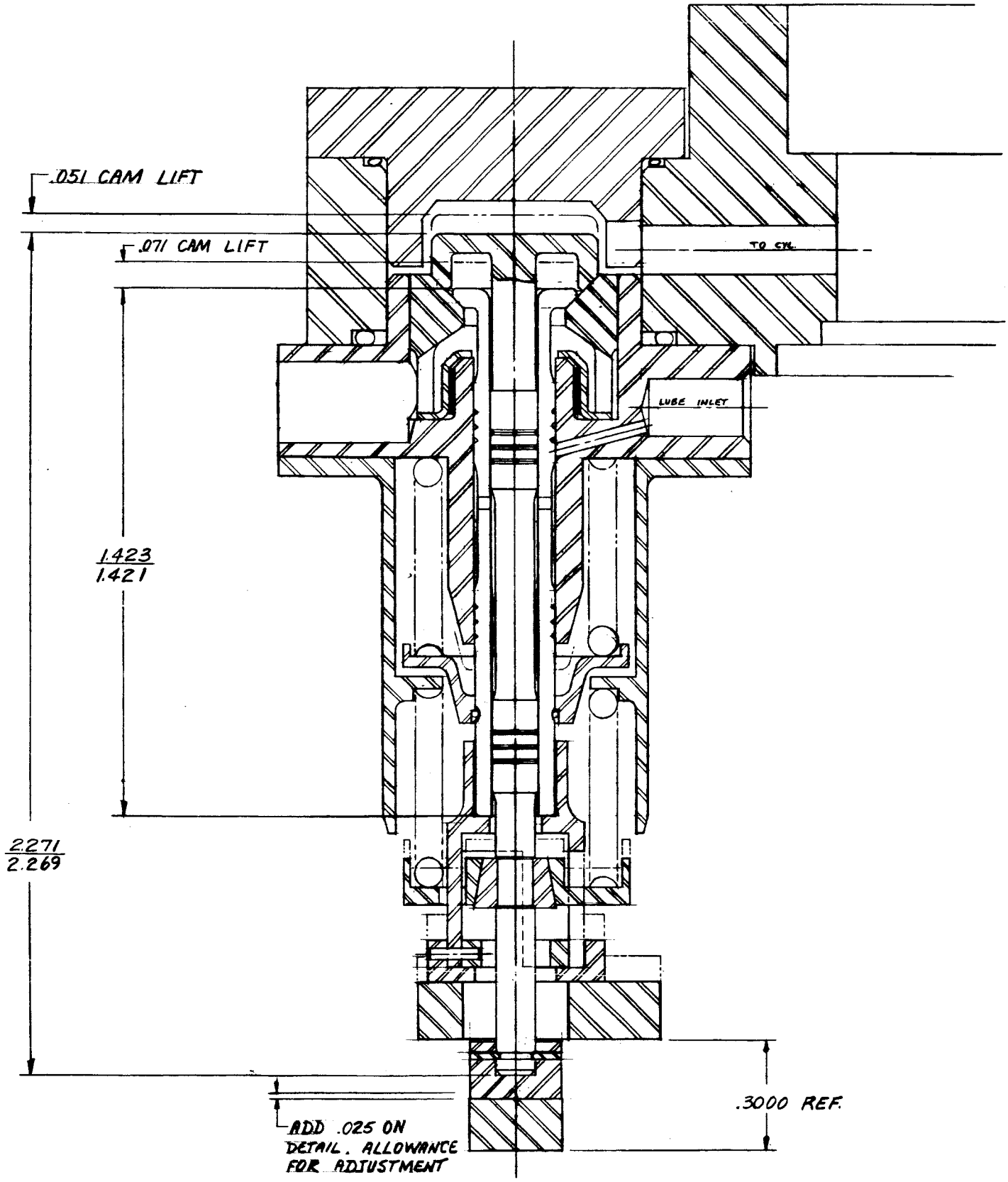


Fig. 2 - Hydrogen Valve Assembly Redesign

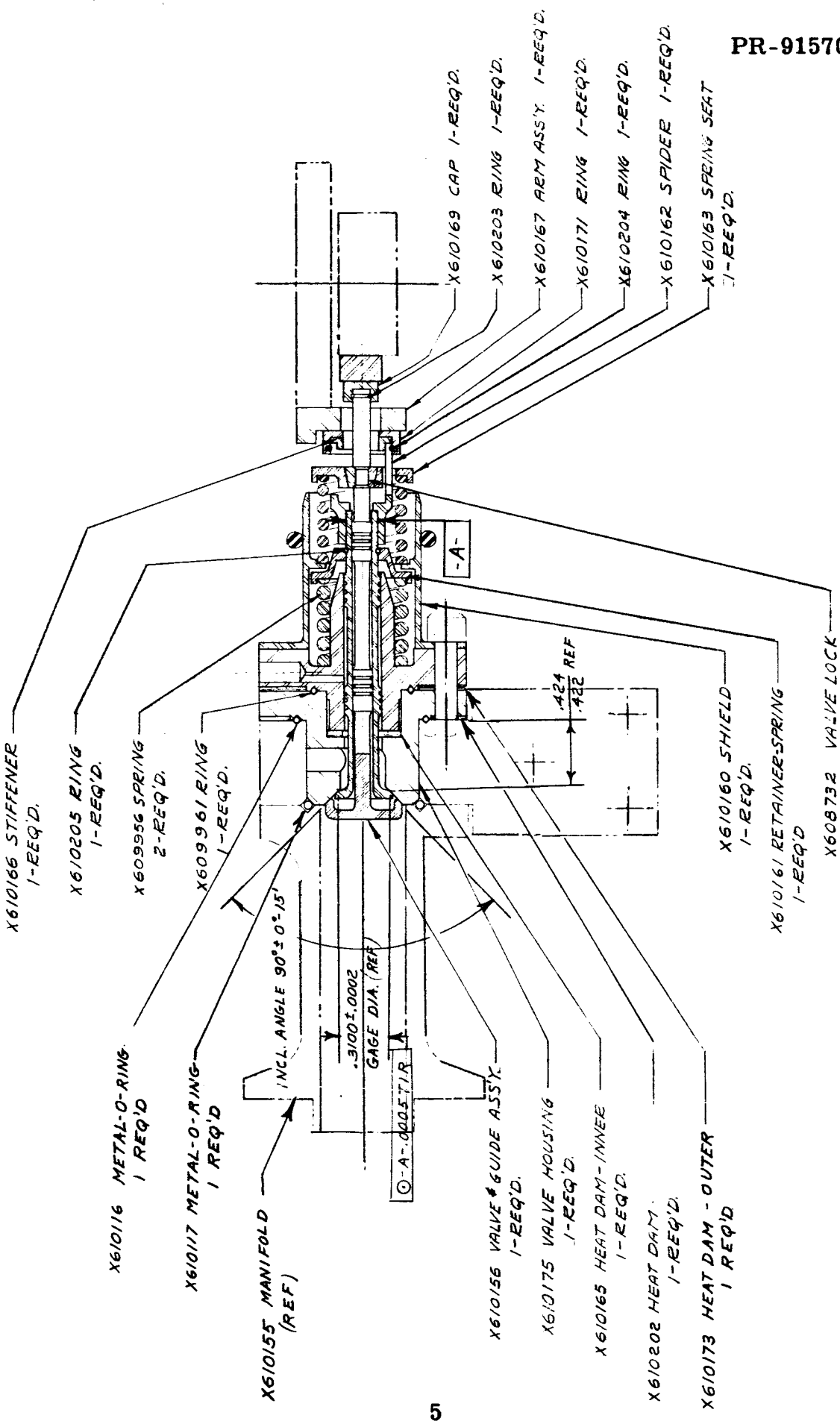


**Fig. 3 - Original Hydrogen Valve Assembly**

Detailing of valve components is approximately 50% complete. Release of drawings for fabrication of parts will start during the week ending September 13, 1963.

2. The oxygen injector cam has been redesigned to increase the cam width to provide larger bearing area. Three blanks have been released. One of these blanks will be contoured per a new cam profile. The new profile is similar to the old cam profile except that the slope of the gradual opening and closing ramps have been increased. This was done because a study of injector clearances indicated the possibility that the old ramps were not high enough and that the initial and final poppet motion may have been occurring while the follower was on the high velocity portions of the cam.

3. Drawings of all new parts required for the redesigned oxygen injector assembly have been released for fabrication.

4. Design study is underway to revise the combustion chamber shape for controlling gas turbulence to improve combustion efficiency. Chamber shape and the use of gas deflector vanes will be investigated. Piston dome and cylinder head modifications are underway.

5. A design concept has been devised which will reduce the effects of thermal expansion upon the oxygen injection. In this design, the rocker shaft bearings are held fixed with respect to the crankcase, and the outer housing of the rocker assembly is split thus allowing

the quill shaft and torsion tube to deflect in bending when the cylinder head and injector body are subjected to radial thermal expansion. The design allows the injector body and cylinder head to move radially with respect to the crankcase without changing the dimensional relationship between the cam follower and cam.

Drawing for rework of old parts and fabrication of new parts required for this design will be prepared and released for fabrication during the next reporting period.

6. A conceptual design study drawing of a new cylinder design has been made. The objectives of this design are to simplify fabrication and to reduce heat transfer from the exhaust gas to the cooling jacket. This design will be evaluated and modified as the design study described below progresses.

7. An engine design and dimensional study is in process. The objectives of this study are to:

   A. Re-evaluate, and change where necessary, the dimensional and tolerance call outs of existing drawings.

   B. Determine which dimensions should be measured, reworked, and recorded during the second engine assembly built up.

   C. Design new piston dome and cylinder head insert configurations intended to improve the combustion process performance.

D. Aid in finalizing the layout of the new cylinder design.

Assembly Build Up

The assembly of one engine is complete. This assembly configuration is essentially the same as was used during the previous program except during the new build up the piston rings were lapped to the cylinder wall with Levigated alumina lapping compound. Components are being inspected and reworked in preparation for the build up of a second assembly.

Performance Tests

During the reporting period, the engine was motored hydraulically for a total of 1.8 hours and operated as an expander for a total of 6.4 hours. A motoring friction test was run with the cylinder head insert removed. The current set of expansion tests will be completed during the next month, and the results will be presented in the next progress report. To date the expansion tests were run with both bottled hydrogen and nitrogen warmed by a 0.5 kw radiant heat lamp. Inlet gas temperatures varied from 140°F to a maximum allowed value of 300°F and crank case temperatures varied between 120°F and 130°F. The heated inlet gas prevented the lubricating oil temperature from dropping below ambient temperature and causing excessively high oil viscosity.

Engine testing was hampered by torque load cell difficulties. A new load cell failed during the first engine run after it was calibrated and had to be returned to the manufacturer for repair.

The load cell used during the above tests required modification of the torque indicator input circuit to provide the proper impedance and instrument response.

The oxygen injector was run on the injector test stand with a dummy weight attached to the rocker arm to simulate the poppet mass to investigate valve drive dynamics by observing rocker arm motion with a strobe light. The stroboscope was timed with a set of modified automotive distributor points driven by the cam shaft and set to "fire" at the maximum poppet lift. Speeds of 2500 to 5000 rpm were run and the rocker arm motion was observed through the inspection port in the injector body, the arm action was steady at all speeds. This test will be repeated on complete injectors assemblies of both the new and old configurations when parts are available.

Regenerator

No work scheduled this reporting period.

Compressor

Drawings were released fabrication of the redesigned drive parts on August 22, 1963. Detail drawings for the new cylinder head design are complete and are being checked. They will be released for fabrication during the week ending September 6, 1963.

An external drive mechanism concept which will reduce vibration has been selected and a layout drawing will be started during the second week of September.

PROTOTYPE ENGINE ENDURANCE TEST

No work scheduled for this reporting period.